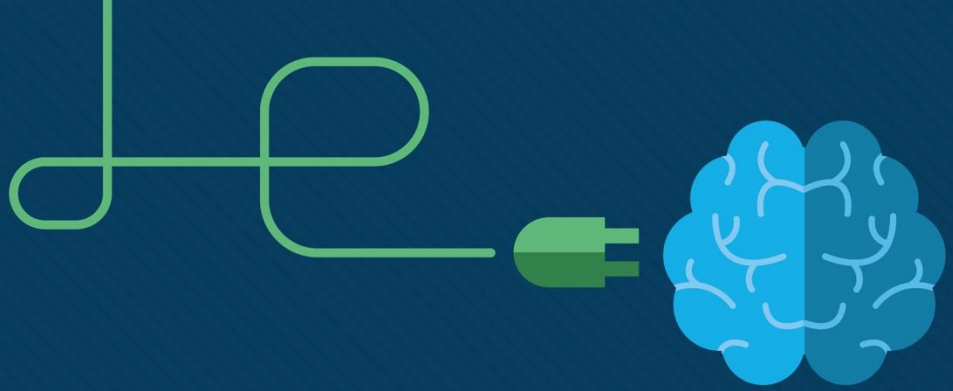


Chapter 1: LAN Design

CCNA Routing and Switching

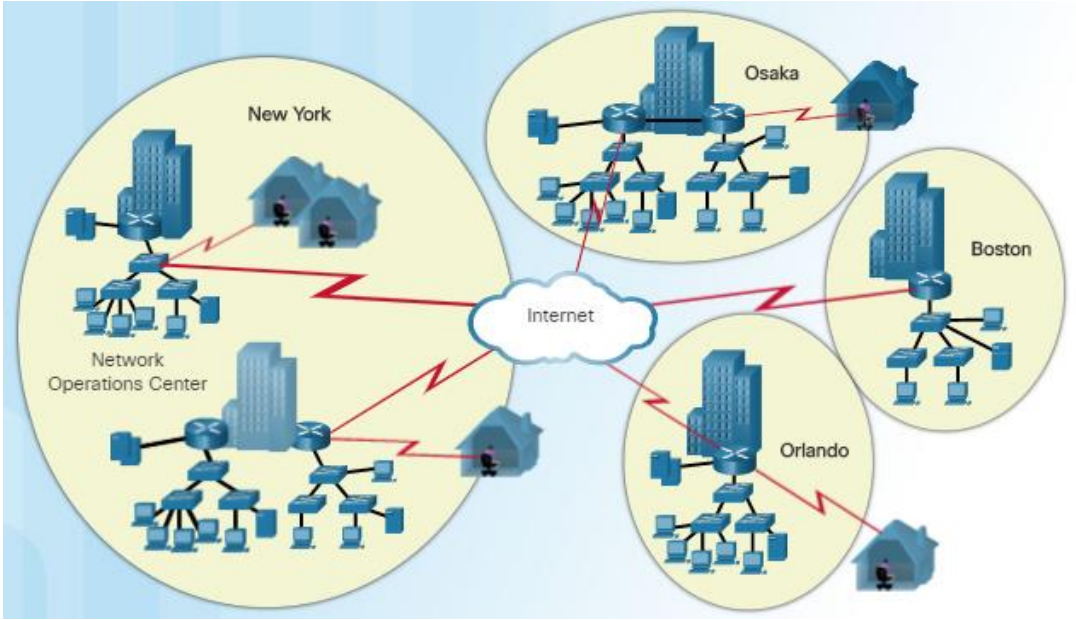
Scaling Networks v6.0

Chapter 1 - Sections & Objectives

- 1.1 Campus Wired LAN Designs
  - Explain why it is important to design a scalable hierarchical network.
    - Describe hierarchical small business network designs.
    - Explain considerations for designing a scalable network.
- 1.2 Campus Network Device Selection
  - Select network devices based on feature compatibility and network requirements.
    - Select the appropriate switch hardware features to support network requirements in small to medium-sized business networks.
    - Describe the types of routers available for small to medium-sized business networks.
    - Configure basic settings on a Cisco IOS device.

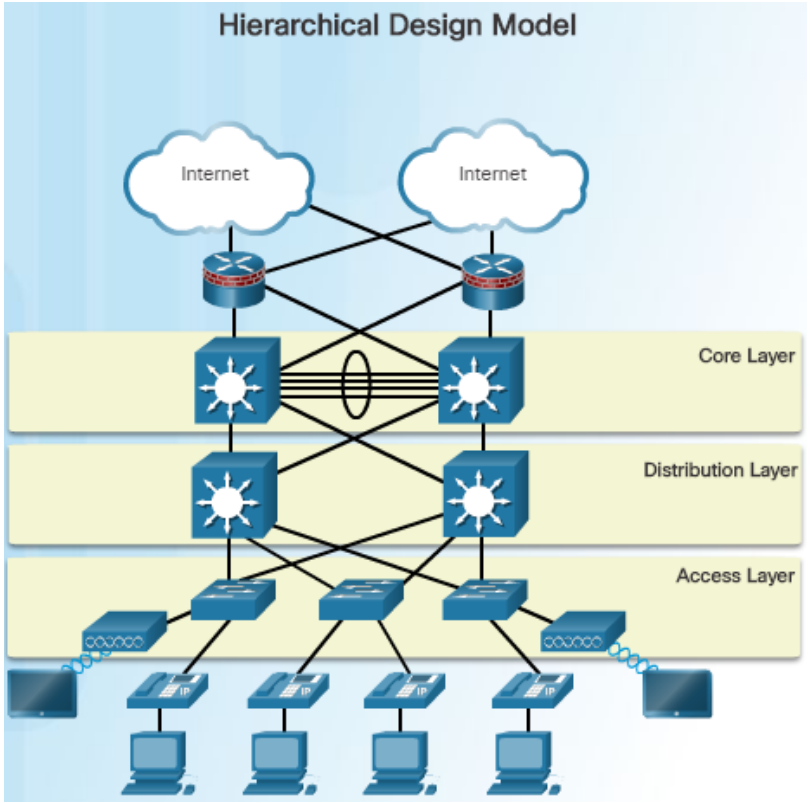
1.1 Campus Wired LAN Designs

The Need to Scale the Network



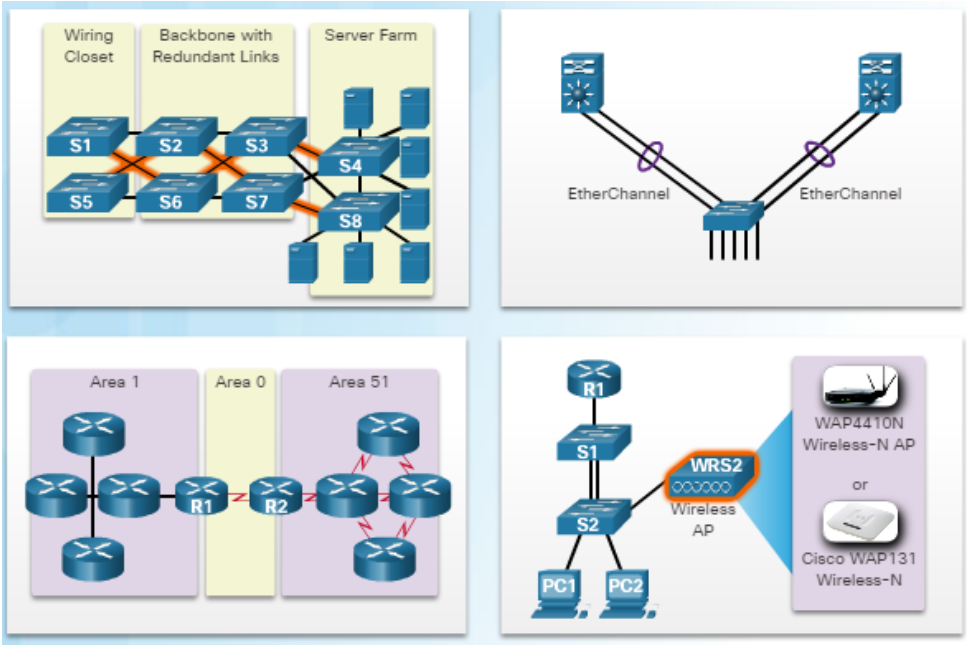
- A company with a small network with one site and a connection to the Internet might grow into an enterprise with a central location with numerous remote sites across the globe.
- All enterprise networks must:
  - Support the exchange of various types of network traffic
  - Support critical applications
  - Support converged network traffic
  - Support diverse business needs
  - Provide centralized administrative control
- The LAN is the networking infrastructure that provides access to network resources for end users over a single floor or a building.

Hierarchical Design Model



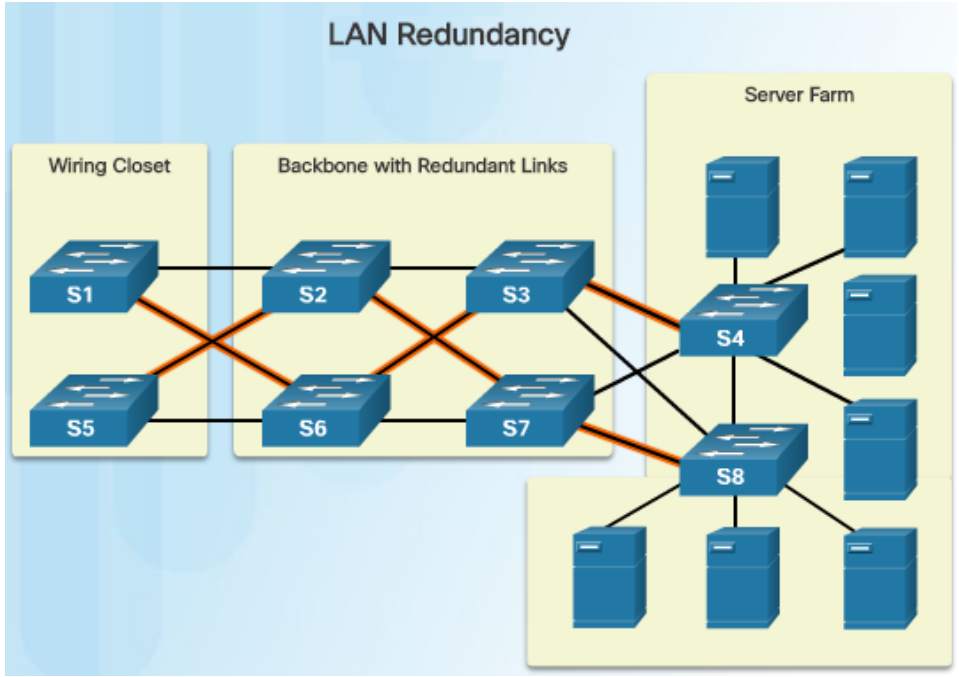
- The campus wired LAN uses a hierarchical design model to break the design up into modular layers.
- Breaking the design up into layers allows each layer to implement specific functions, which simplifies the network design for easier deployment and management.
- A hierarchical LAN design includes three layers as shown in the figure:
  - Access layer
  - Distribution layer
  - Core layer
- Some smaller enterprise networks implement a two-tier hierarchical design and collapse the core and distribution layers into one layer.

Design for Scalability



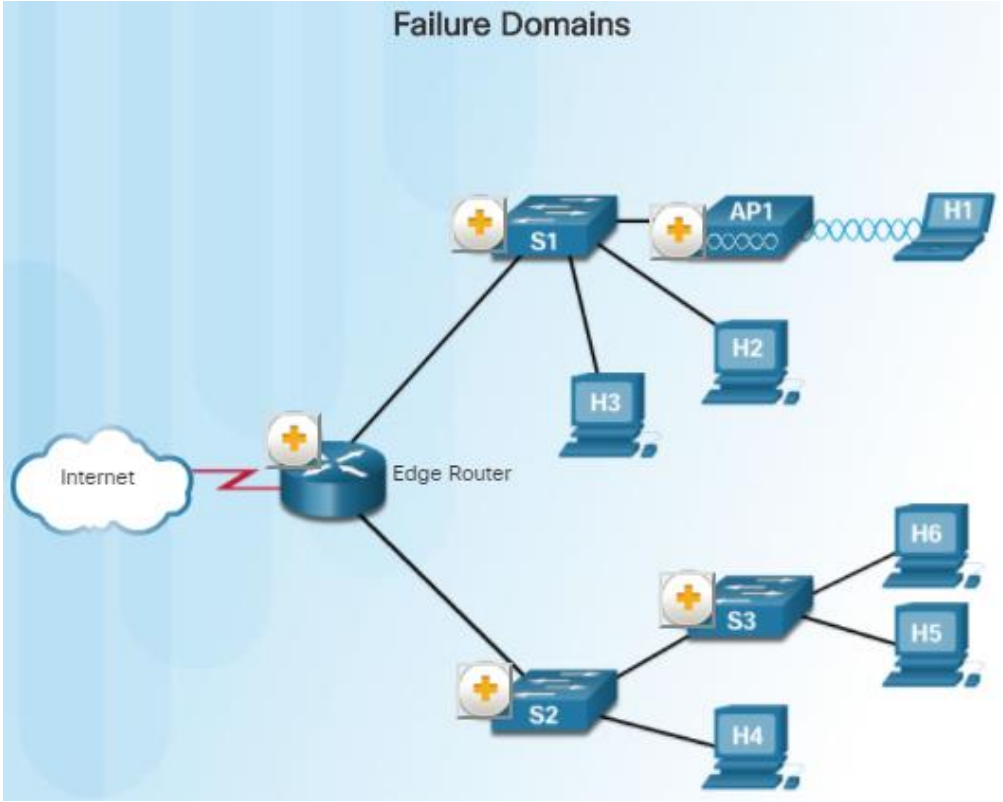
- The network designer must develop a strategy to enable the network to be available and scale easily and effectively.
- **Use expandable, modular** equipment or clustered devices that can be easily upgraded to increase capabilities.
- **Design a hierarchical** network to include modules that can be added, upgraded, and modified as needed.
- **Create an IPv4 or IPv6** address strategy that is hierarchical.
- **Choose routers or multilayer switches** to limit broadcasts and filter undesirable traffic from the network.
- **Implement redundant links** between critical devices and between access and core layers.

Planning for Redundancy



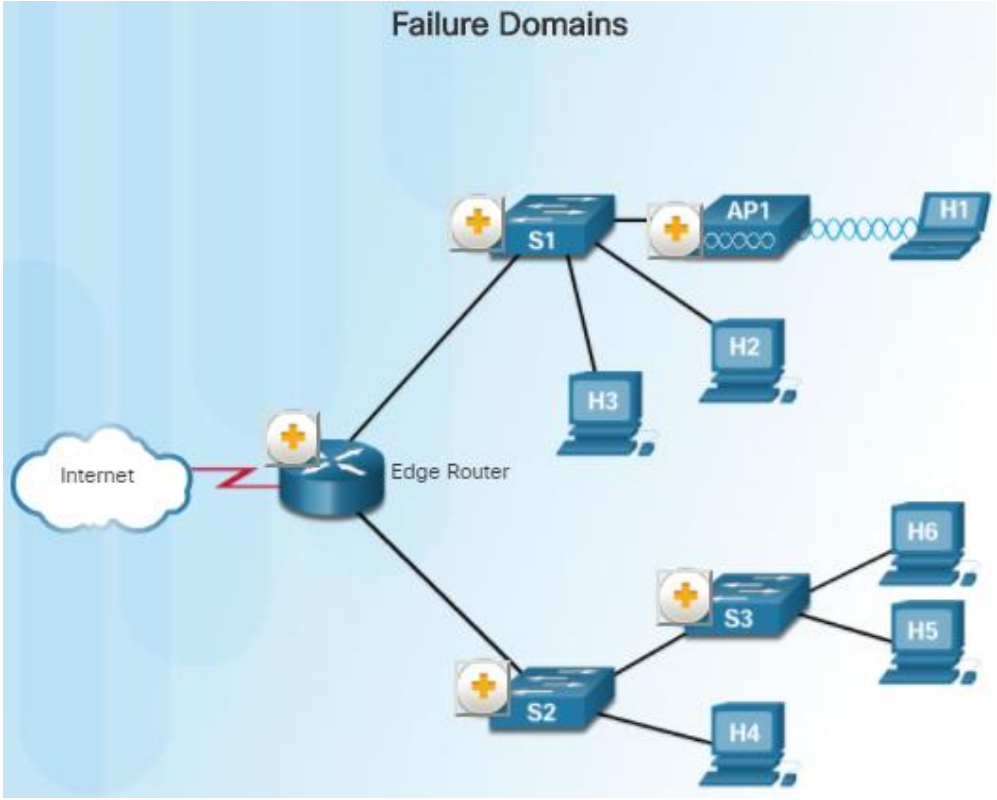
- Redundancy is an important part of the network design for preventing disruption of network services.
- Minimize the possibility of a single point of failure by recognizing these facts:
  - Installing duplicate equipment and providing failover services for critical devices is necessary.
  - Redundant paths offer alternate physical paths for data to traverse the network.
  - Spanning Tree Protocol (STP) is required with redundant paths in a switched Ethernet network to prevent Layer 2 loops.
- STP provides a mechanism for disabling redundant paths in a switched network until the path is necessary such as when a failure occurs.

Failure Domains



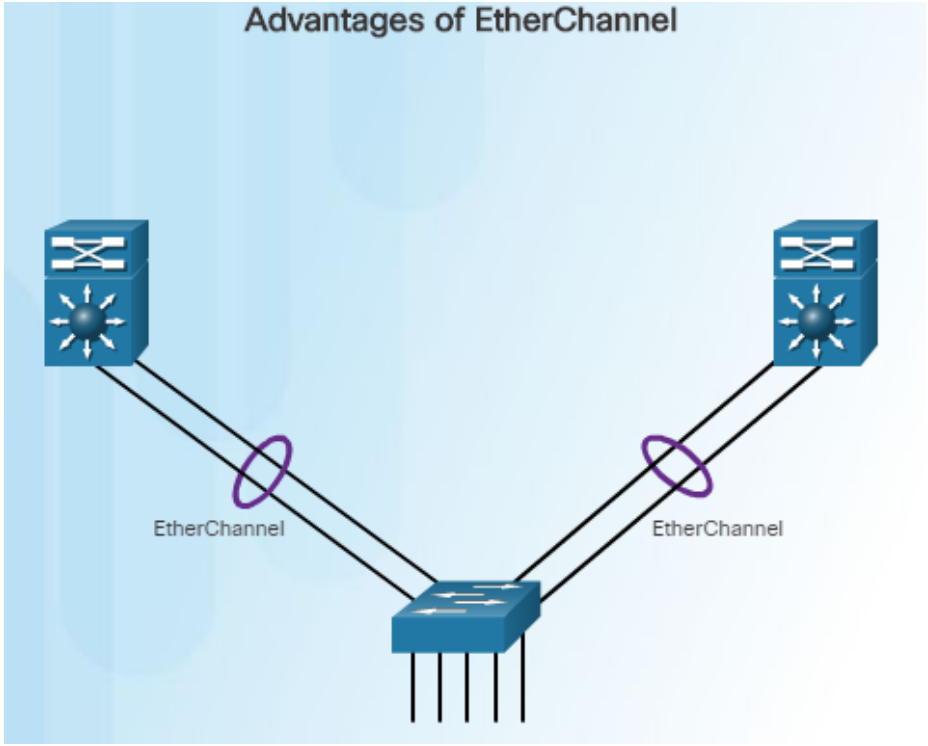
- A well-designed network should limit the size of failure domains.
- A **failure domain** is the area of a network that is impacted when a critical device or network service experiences problems.
- The function of the devices that fail will determine the impact of the failure domain.
- Use redundant links and reliable enterprise-class equipment to minimize the disruption in a network.
- Smaller failure domains reduce the impact of a failure but also make troubleshooting easier.

Failure Domains (Cont.)



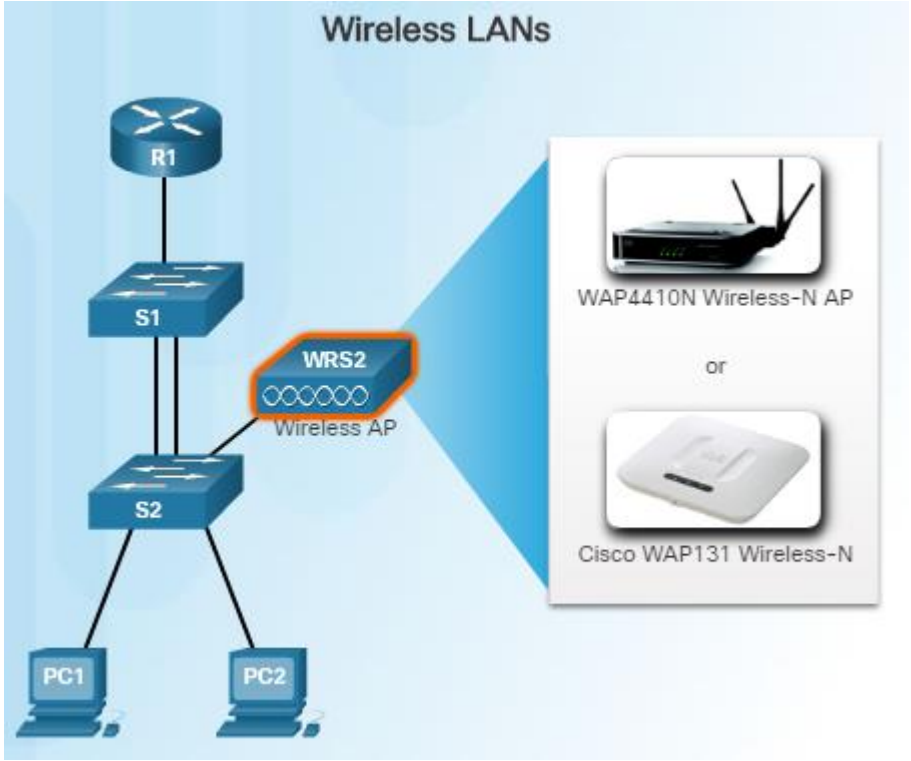
- In the hierarchical design model, it is usually easier to control the size of a failure domain in the distribution layer.
- In the distribution layer, network errors can be contained to a smaller area which will impact fewer users.
- When using Layer 3 devices at the distribution layer, every router functions as a gateway for a limited number of access layer users.
- Switch Block Deployment
  - Routers or multilayer switches are usually deployed in pairs with access layer switches evenly divided between them.
  - Each switch block acts independently of the others, which reduces the impact of failures.

Increasing Bandwidth



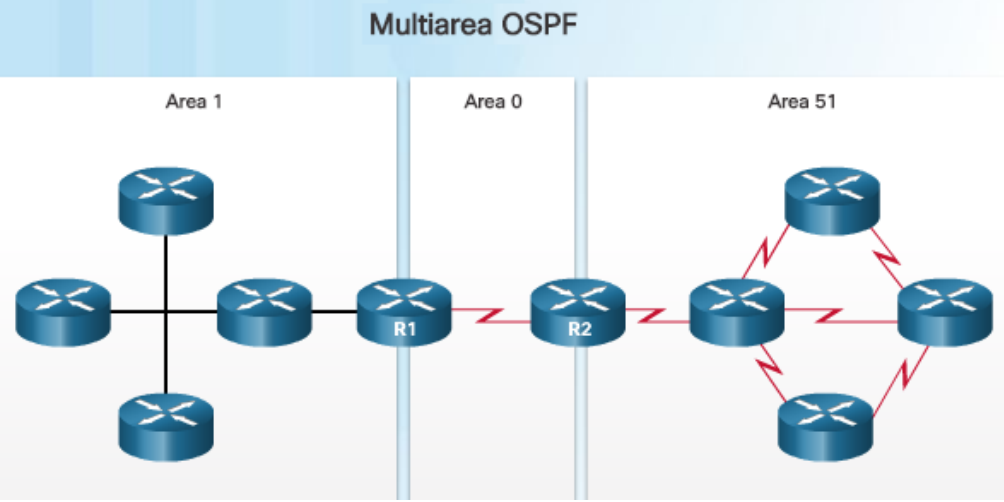
- In a hierarchical network design, some links between access and distribution layer switches may need to process a greater amount of traffic than other links do.
- As multiple links converge into a single link, it is possible for this link to become a bottleneck.
- **EtherChannel** is a form of link aggregation that will allow the network administrator to increase the amount of bandwidth between devices by creating one logical link out of several physical links.
- EtherChannel uses existing switch ports.
- The EtherChannel configuration takes advantage of load balancing between links that are part of the same EtherChannel.

Expanding the Access Layer



- Wireless connectivity is an important aspect of extending access layer connectivity.
- The network must be designed to be able to expand network access to individuals and devices, as needed.
- **Advantages** of wireless connectivity include increased flexibility, reduced cost, and the ability to adapt to changing network and business requirements.
- End devices require a wireless NIC that incorporates a radio transmitter/receiver, appropriate software drivers, and also a wireless access point (AP) to connect to.

Fine-tuning Routing Protocols



- OSPF supports a two-layer hierarchical design, referred to as multiarea OSPF.
- Multiarea OSPF requires an Area 0 (backbone area)
- Non-backbone areas must be directly connected to Area 0.

- Advanced routing protocols, such as OSPF and EIGRP are used in large networks.
- Link-state routing protocols such as OSPF works well for larger hierarchical networks where fast convergence is important.
- Single Area OSPF has one area – Area 0.
- Cisco's proprietary distance vector routing protocol, called EIGRP, is another popular routing protocol. It is designed for larger networks using primarily Cisco routers.
- Although the configuring EIGRP is simple, the underlying features and options of EIGRP are extensive and robust.

1.2 Selecting Network Devices

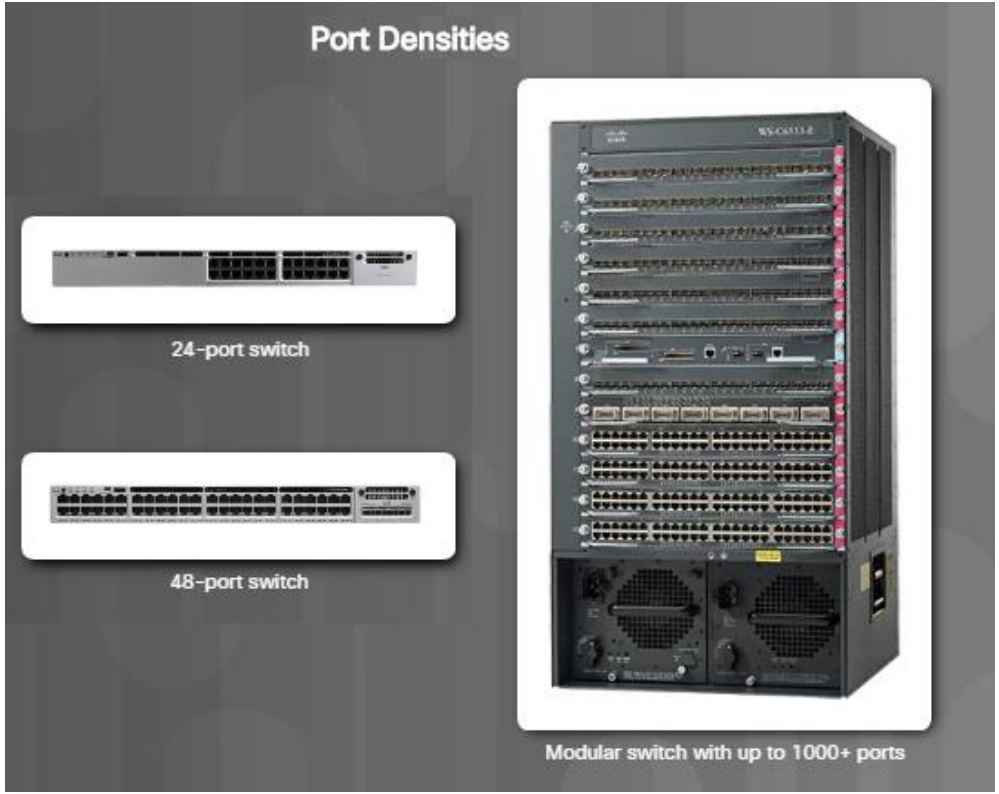
Switch Platforms

- The chassis accepts line cards that contain the ports

- Selecting the proper hardware to meet the current network requirements is critical when designing a network.
- There are five categories of switches for enterprise networks:
  - Campus LAN switches
  - Cloud-managed switches

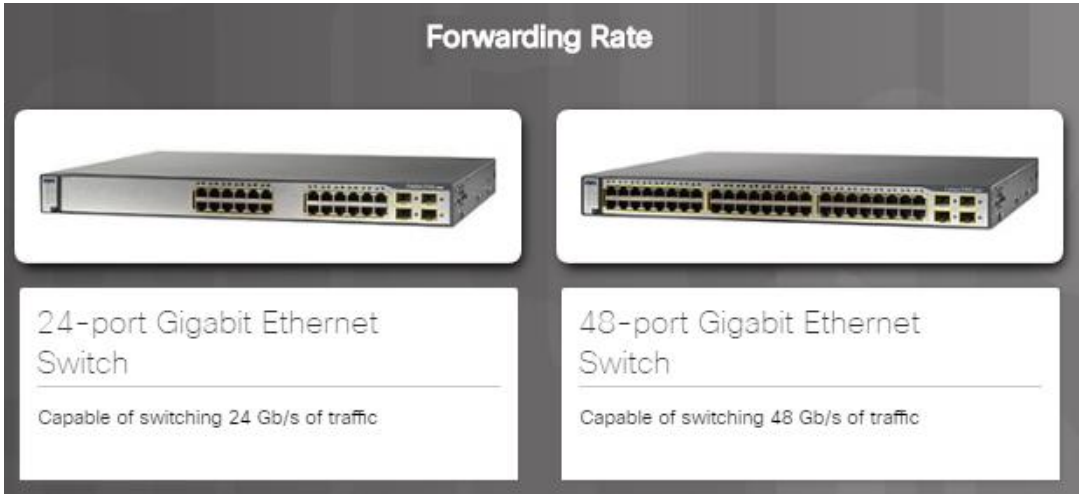
    https://www.youtube.com/watch?v=GbsR6zt_KpI
  - Data center switches
  - Service provider switches
  - Virtual networking
- Various factors to consider when selecting switches include these:
  - Fixed vs. modular configuration
  - Stackable vs. nonstackable
  - Thickness of the switch (rack units)
  - Cost, port density, power, reliability

Port Density



- The port density of a switch refers to the number of ports on a single switch.
- Fixed configuration switches support a variety of port density configurations:
  - Cisco Catalyst 3850 24 port and 48 port switches (see figure)
  - The 48 port switch has an option for four additional ports for pluggable SFP devices.
- The modular Catalyst 6500 switch shown in the figure can support over 1,000 switch ports.
- Modular switches are usually more appropriate in large networks in order to reduce space and power issues.

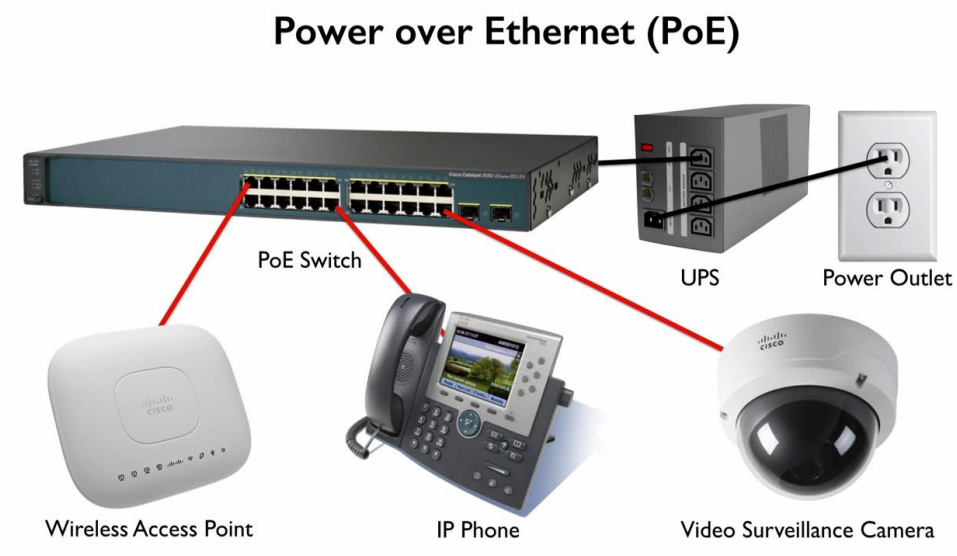
Forwarding Rates



- Switch product lines are classified by forwarding rates.
- Forwarding rates define the processing capabilities of a switch by rating how much data the switch can process per second.

- Entry-level switches have lower forwarding rates than enterprise-level switches.
- Forwarding Rates are an important factor when selecting a switch because if the rate is too low, it will not be able to support full wire-speed communication across all of its switch ports.
- Access layer switches typically do not need to operate at full wire speed because they are physically limited by their uplinks to the distribution layer.
- Higher performing switches are needed at the distribution and core layers.

Power over Ethernet



https://www.cisco.com/c/en/us/products/switches/index.html

https://blogs.cisco.com/manufacturing/cisco-power-over-ethernet-poe-whats-the-benefit-to-your-business

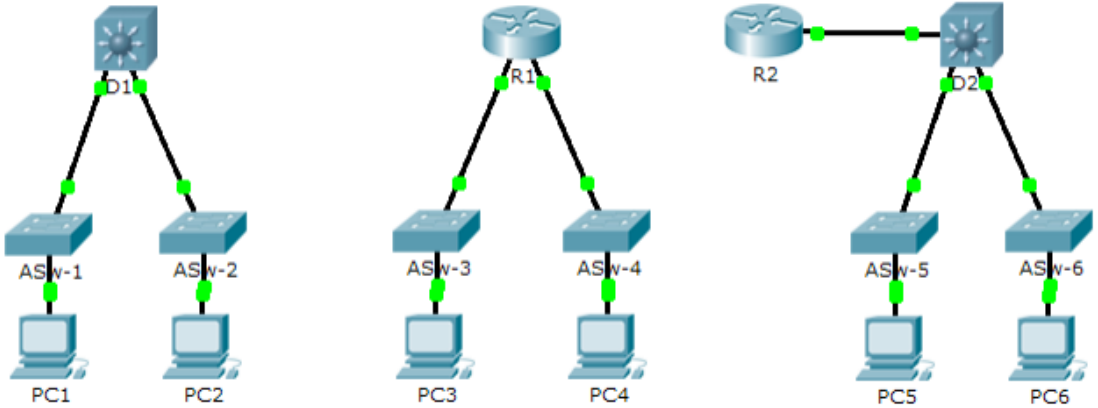
- PoE allows the switch to deliver power to a device over the existing Ethernet cabling.
- This eliminates the need for a power cable to the networked device such an IP phone or wireless access point.
- PoE allows more flexibility when installing wireless access points and IP phones by allowing them to be installed anywhere that there is an Ethernet cable.
- The Cisco Catalyst 2960-C and 3560-C Series compact switches support PoE pass-through.
- PoE pass-through devices can power PoE devices as well as the switch itself by drawing power from certain upstream switches.

Multilayer Switching

- Multilayer switches are typically deployed in the core and distribution layer.
- Multilayer switches can do the following:
  - Build a routing table and support routing protocols
  - Forward IP packets at a rate close to that of Layer 2 forwarding
- Multilayer switches often support specialized hardware called application-specific integrated circuits (ASICs).
- ASICs along with dedicated software can streamline the forwarding of IP packets independent of the CPU.
- There is a trend in networking toward a pure Layer 3 switched environment.

Packet Tracer – Comparing 2960 and 3560 Switches

Topology



Objective

Part 1: Compare Layer 2 and Layer 3 Switches

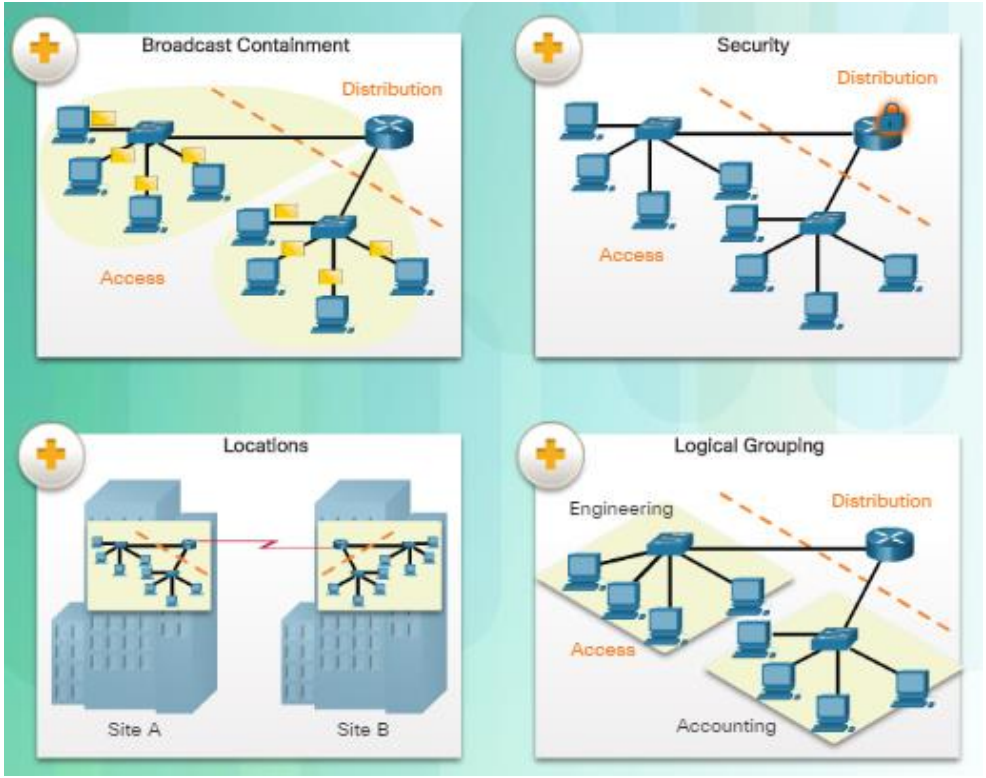
Part 2: Compare a Layer 3 Switch and a Router

Background

In this activity, you will use various commands to examine three different switching topologies and compare the similarities and differences between the 2960 and 3560 switches. You will also compare the routing table of a 1941 router with a 3560 switch.

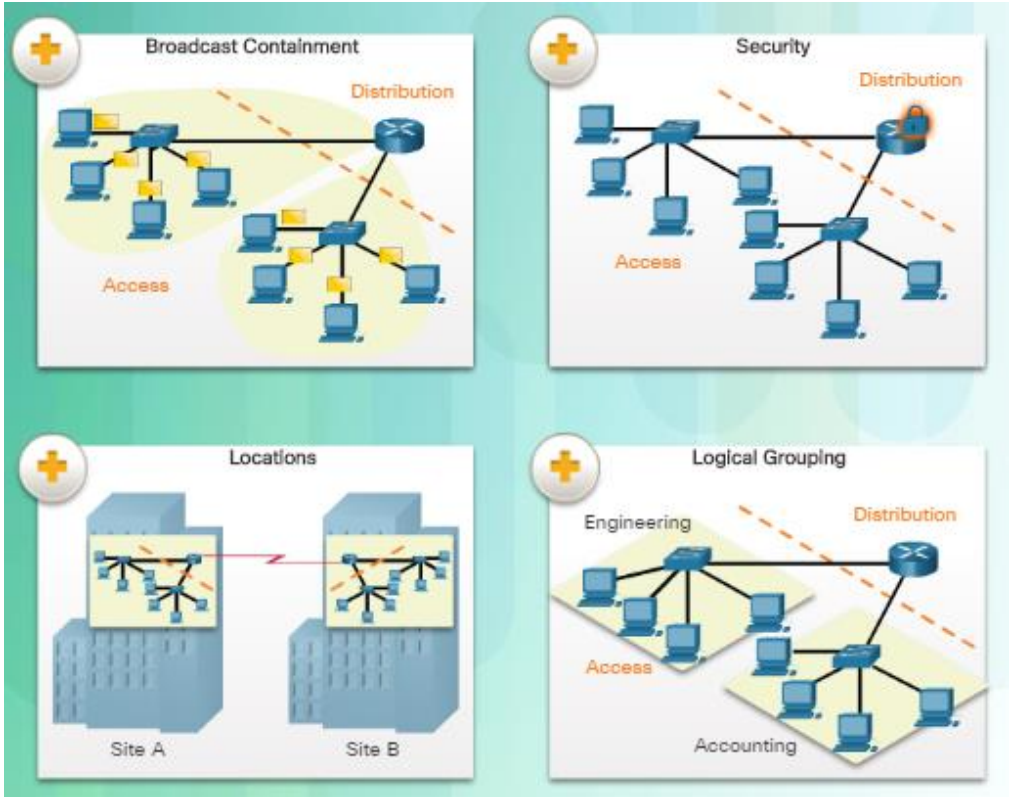
- This Packet Tracer activity will allow you to use various commands to compare and examine three different switching topologies and compare the 2960 and 3560 switches.
- You will also compare the routing table of a 1941 router and a 3560 switch.

Router Requirements



- Routing is required within the distribution layer of an enterprise network. Without routing, packets could not leave the local network.
- Routers are critical networking devices because they are responsible for:
  - Connecting businesses and homes to the Internet
  - Interconnecting multiple sites within an enterprise network
  - Connecting ISPs on the Internet
  - Translating between different media types and protocols
  - Finding alternate paths if a link or path goes down

Router Requirements (Cont.)

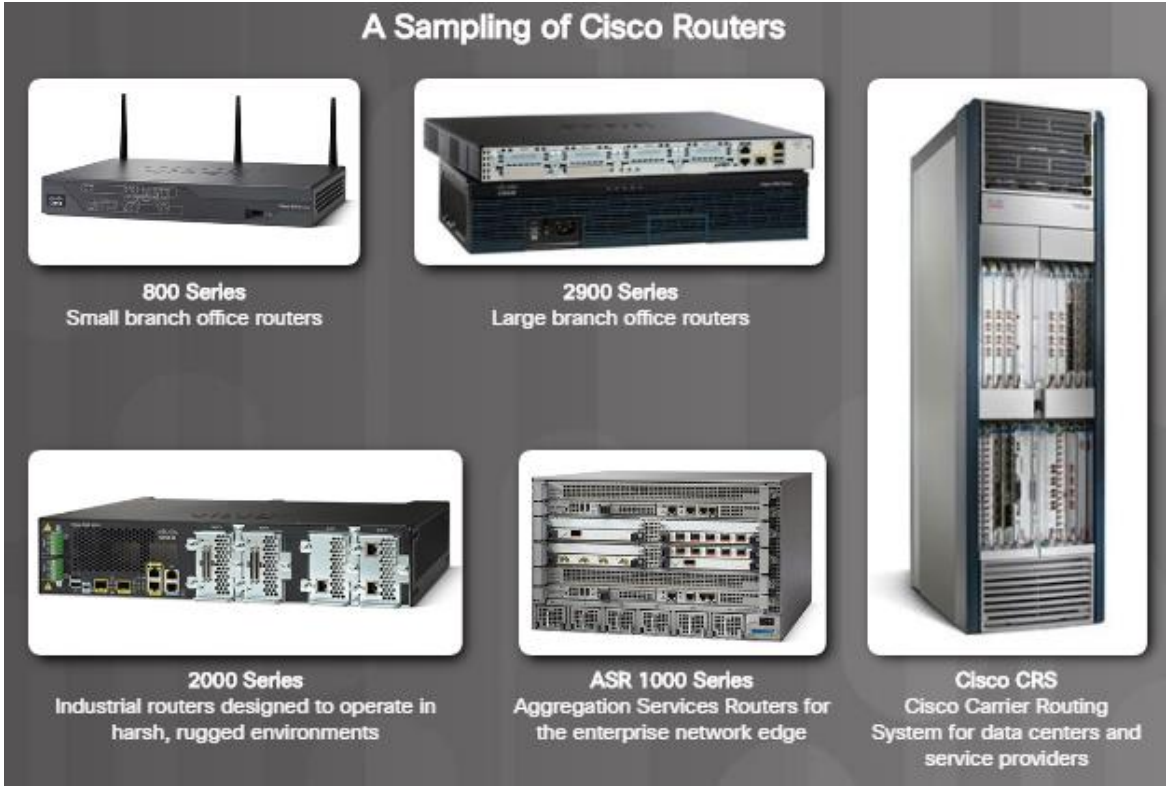


- Routers also serve other important functions:
  - Provide broadcast containment by limiting broadcasts to the local network
  - Group users logically by application or department
  - Provide enhanced security through the use of access control lists in order to filter unwanted traffic.
  - Interconnect geographically separated locations.

Cisco Routers

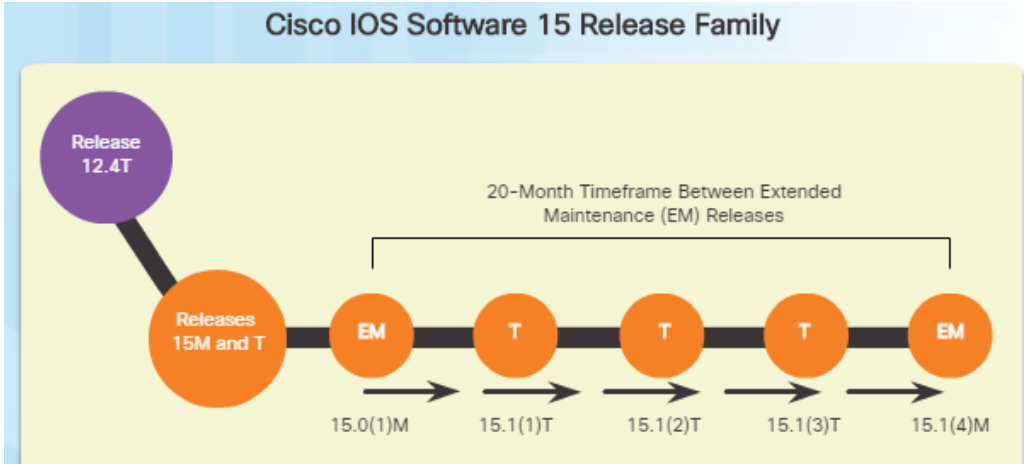
- Selecting the proper router or routers is an important task for the network administrator in order to accommodate a growing network. There are three categories of routers:
  - Branch routers – Branch routers optimize branch services on a single platform while delivering an optimal application experience across branch and WAN infrastructures.
  - Network edge routers – Network edge routers enable the network edge to deliver high-performance, highly secure, and reliable services that unite campus, data center, and branch networks.
  - Service provider routers – Service provider routers differentiate the service portfolio and increase revenues by delivering end-to-end scalable solutions and subscriber-aware services.

Router Hardware



- Routers come in many forms:
  - They range in size from a small desktop router to a rack-mounted or blade model router.
  - They can be categorized as fixed configuration or modular.
  - They come with a variety of interfaces such as Fast Ethernet, Gigabit Ethernet, Serial, and fiber-optic.
- As an example, the Cisco 1941 router comes with two Gigabit Ethernet RJ-45 interfaces built-in and two slots that can accommodate many different network interface modules.

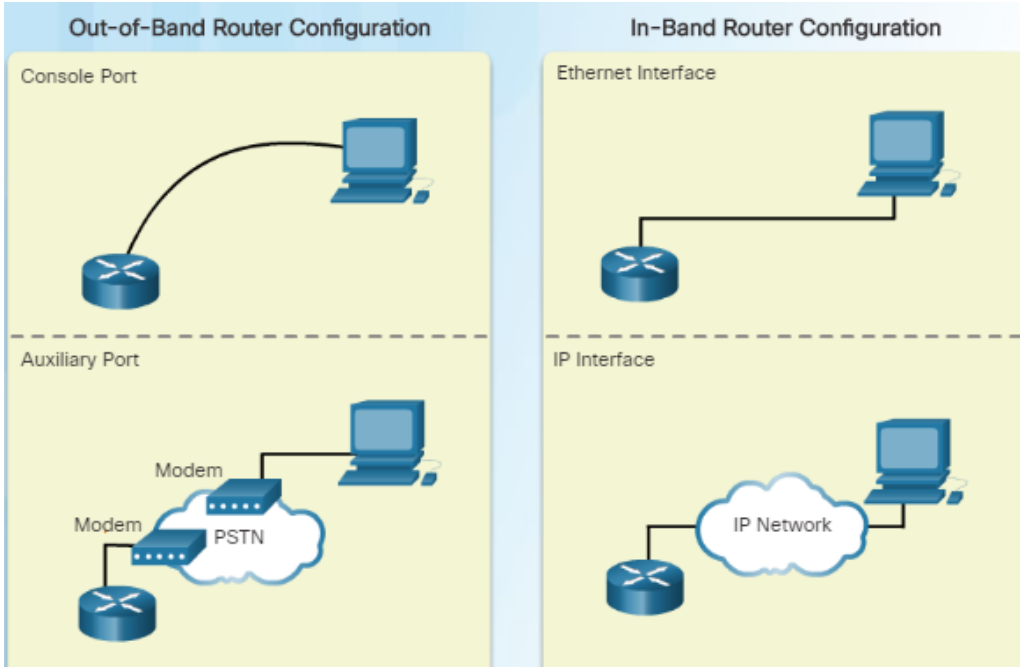
Managing IOS Files and Licensing



- For routers beginning with Cisco IOS Software release 15.0, Cisco modified the process to enable new technologies within the IOS feature sets.

- When selecting or upgrading a Cisco IOS device, it is important to choose the proper IOS image with the correct feature set and version.
- IOS refers to the package of routing, switching, security, and other internetworking technologies integrated into a single multitasking operating system.
- When a new device is shipped, it comes preinstalled with the software image and corresponding permanent licenses for the customer-specified packages and features.

In-band versus Out-of-band Management



- There are two methods for connecting a PC to a network device for configuration and monitoring tasks:
  - Out-of-band management through the use of the console or AUX port is used for the initial configuration or when a network connection is not available.
  - In-band management is used to configure or monitor the device remotely through a network connection using either SSH or HTTPs.
    - A reachable and operational network interface is required.
    - For security reasons, the use of Telnet and HTTP are not recommended.

Basic Router CLI Commands

```
Building configuration...

Current configuration : 1189 bytes
!
version 15.1
no service timestamps log datetime msec
no service timestamps debug datetime msec
service password-encryption
!
hostname AJO
!
enable secret 5 $1$mERr$61vV8.63KlvsvURT4RqoW/
!
!
!
no ip domain-lookup
!
!
```

```
interface GigabitEthernet0/0
ip address 163.70.84.1 255.255.252.0
duplex auto
speed auto
!
interface Serial0/0/0
no ip address
clock rate 2000000
shutdown
!
interface Serial0/1/0
description Link to COL
ip address 163.70.12.1 255.255.252.0
clock rate 128000
!
interface Serial0/1/1
ip address 163.70.20.1 255.255.252.0
clock rate 128000
!
```

Basic Router CLI Commands

```
router rip
network 163.70.0.0
!
ip classless
!
banner motd ^CMuerte a los vampiros!^C
!
line con 0
password 7 082F595A1B10111E040A1F
login
!
line aux 0
!
line vty 0 4
password 7 082F595A1B10111E040A1F
login
line vty 5 15
password 7 082F595A1B10111E040A1F
login
!
```

Basic Router Show Commands

```
Routing Protocol is "rip"
Sending updates every 30 seconds, next due in 22 seconds
Invalid after 180 seconds, hold down 180, flushed after 240
Outgoing update filter list for all interfaces is not set
Incoming update filter list for all interfaces is not set
Redistributing: rip
Default version control: send version 1, receive any version
  Interface              Send  Recv  Triggered RIP  Key-chain
  GigabitEthernet0/0     1     2 1
  Serial0/1/0            1     2 1
  Serial0/1/1            1     2 1
Automatic network summarization is in effect
Maximum path: 4
Routing for Networks:
          163.70.0.0
Passive Interface(s):
Routing Information Sources:
          Gateway         Distance      Last Update
          163.70.15.254         120      00:00:17
          163.70.23.254         120      00:00:26
Distance: (default is 120)
```

Basic Router Show Commands (Cont.)

```
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter
area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

     163.70.0.0/16 is variably subnetted, 8 subnets, 2 masks
C       163.70.12.0/22 is directly connected, Serial0/1/0
L       163.70.12.1/32 is directly connected, Serial0/1/0
C       163.70.20.0/22 is directly connected, Serial0/1/1
L       163.70.20.1/32 is directly connected, Serial0/1/1
C       163.70.84.0/22 is directly connected, GigabitEthernet0/0
L       163.70.84.1/32 is directly connected, GigabitEthernet0/0
R       163.70.100.0/22 [120/1] via 163.70.15.254, 00:00:20, Serial0/1/0
R       163.70.108.0/22 [120/1] via 163.70.23.254, 00:00:22, Serial0/1/1
```

Basic Router Show Commands (Cont.)

```
GigabitEthernet0/0 is up, line protocol is up (connected)
  Hardware is CN Gigabit Ethernet, address is 0000.0c8c.9201 (bia
0000.0c8c.9201)
  Internet address is 163.70.84.1/22
  MTU 1500 bytes, BW 1000000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Keepalive set (10 sec)
  Full-duplex, 100Mb/s, media type is RJ45
  output flow-control is unsupported, input flow-control is unsupported
  ARP type: ARPA, ARP Timeout 04:00:00,
  Last input 00:00:08, output 00:00:05, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0 (size/max/drops); Total output drops: 0
  Queueing strategy: fifo
  Output queue :0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 32 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 watchdog, 1017 multicast, 0 pause input
     0 input packets with dribble condition detected
```

Basic Router Show Commands (Cont.)

```
GigabitEthernet0/0 is up, line protocol is up (connected)
  Internet address is 163.70.84.1/22
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is not set
  Directed broadcast forwarding is disabled
  Outgoing access list is not set
  Inbound  access list is not set
  Proxy ARP is enabled
  Security level is default
  Split horizon is enabled
  ICMP redirects are always sent
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  IP fast switching is disabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP Fast switching turbo vector
  IP multicast fast switching is disabled
  IP multicast distributed fast switching is disabled
  Router Discovery is disabled
  IP output packet accounting is disabled
  IP access violation accounting is disabled
  TCP/IP header compression is disabled
  RTP/IP header compression is disabled
```

Basic Router Show Commands (Cont.)

```
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0     163.70.84.1     YES manual up                    up
GigabitEthernet0/1     unassigned      YES unset  administratively down down
Serial0/0/0            unassigned      YES unset  administratively down down
Serial0/0/1            unassigned      YES unset  administratively down down
Serial0/1/0            163.70.12.1     YES manual up                    up
Serial0/1/1            163.70.20.1     YES manual up                    up
Vlan1                  unassigned      YES unset  administratively down down
```

Basic Router Show Commands (Cont.)

```
Global values:
  Internet Protocol routing is enabled
GigabitEthernet0/0 is up, line protocol is up
  Internet address is 163.70.84.1/22
GigabitEthernet0/1 is administratively down, line protocol is down
Serial0/0/0 is administratively down, line protocol is down
Serial0/0/1 is administratively down, line protocol is down
Serial0/1/0 is up, line protocol is up
  Internet address is 163.70.12.1/22
Serial0/1/1 is up, line protocol is up
  Internet address is 163.70.20.1/22
Vlan1 is administratively down, line protocol is down
```

Basic Router Show Commands (Cont.)

```
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone
Device ID     Local Intrfce   Holdtme    Capability   Platform    Port ID
COL           Ser 0/1/0        153           R       C1900       Ser 0/0/0
NOPAL         Ser 0/1/1        155           R       C1900       Ser 0/0/0
```

Basic Switch CLI Commands

Enable Switch

```
Switch# enable
Switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)# hostname S1
S1(config)# banner motd %Unauthorized access prohibited%
S1(config)# enable password cisco
S1(config)# enable secret class
S1(config)# line con 0
S1(config-line)# password cisco
S1(config-line)# login
S1(config-line)# line vty 0 4
S1(config-line)# password cisco
S1(config-line)# login
S1(config-line)# interface vlan 1
S1(config-if)# ip address 192.168.1.5 255.255.255.0
S1(config-if)# no shutdown
S1(config-if)# exit
S1(config)# ip default-gateway 192.168.1.1
S1(config)# interface fa0/2
S1(config-if)# switchport mode access
S1(config-if)# switchport port-security
S1(config-if)# interface fa0/3
S1(config-if)# speed 10
S1(config-if)# duplex half
S1(config)# end
00:12:31: %SYS-5-CONFIG_I: Configured from console by console
S1#
```

- Basic switch configuration includes these:
  - Hostname for identification
  - Passwords for security
  - Assignment of IP addresses for connectivity. In band-access requires the switch to have an IP address.
- See the figure on the left for the commands used to enable and configure the switch.
- Use the **copy running-config startup-config** command to verify and save the switch configuration.
- Use the **erase startup-config** and **reload** commands to clear the switch configuration.

Basic Switch Show Commands

```
S1# show port-security interface fastethernet 0/19
Port Security              : Enabled
Port Status                : Secure-up
Violation Mode             : Shutdown
Aging Time                 : 0 mins
Aging Type                 : Absolute
SecureStatic Address Aging : Disabled
Maximum MAC Addresses      : 50
Total MAC Addresses        : 1
Configured MAC Addresses   : 0
Sticky MAC Addresses       : 1
Last Source Address:Vlan   : 0025.83e6.4b02:1
Security Violation Count   : 0
```

```
S1# show mac-address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----
 All    0014.6954.2480    STATIC       CPU
 All    0100.0ccc.cccc    STATIC       CPU
 All    0100.0ccc.cccd    STATIC       CPU
 All    0100.0cdd.dddd    STATIC       CPU
   1    000b.be02.a841    DYNAMIC      Fa0/1
   1    000c.2999.758e    DYNAMIC      Fa0/2
   1    000c.29c4.9e26    DYNAMIC      Fa0/3
   1    000c.29ff.0744    DYNAMIC      Fa0/1
   1    0014.6a46.e1c8    DYNAMIC      Fa0/2
   1    0014.6a46.e1c9    DYNAMIC      Fa0/3
   1    0016.763f.935d    DYNAMIC      Fa0/3
Total Mac Addresses for this criterion: 11
```

- Switches make use of common IOS commands for configuration, to check for connectivity, and to display current switch status. Here are some very useful commands:
  - **show port-security** – Displays any ports with security activated. Include the interface ID to examine a specific interface.
  - **show port-security address** – Displays all secure MAC addresses configured on all switch interfaces.
  - **show interfaces** – Displays one or all interfaces with line protocol status, bandwidth, delay, reliability, encapsulation, duplex, and I/O statistics.
  - **show mac-address-table** – Displays all MAC addresses that the switch has learned, how they were learned, port number, and the VLAN assigned to the port.
- Cisco switches also support the **show cdp neighbors command.**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